Lasers in dental traumatology

Aim Dental traumas are frequent in children. They can be complex events and sometimes real emergencies. Since very little attention is devoted to this topic in the international literature and there are no well-coded laser guidelines for these specific clinical events, our aim is to consider and present those situations in which laser-assisted therapy can offer new treatment possibilities. The authors’ aim is to stimulate more extensive scientific research in this area, which might not only increase the use of these technologies, but also improve outcomes and reduce complications connected to dental trauma, particularly in children. Furthermore, laser-assisted therapies drastically reduce the need for analgesics and anti-inflammatory medications compared with conventional procedures.

Conclusion Using laser equipment to obtain anaesthesia is another challenge, while the use of low power setting for desensitising tissue and to obtain anaesthesia is also an open field.

Keywords: dental trauma, paediatric dentistry, erbium laser.

Introduction

Dental traumas are frequent in children (around 20% of children suffer a traumatic injury to their primary teeth and over 15% to their permanent teeth) [Andreasen et al., 2007; Glendor, 2008] and they can be complex events, sometimes real emergencies. The management of a dental trauma in children can be complicated by their young age (in particular their emotional status and inability to cooperate), the severity of the event or a late intervention. An effective operative protocol, including a correct diagnosis, an effective control of pain, a rapid and correct intervention, may strongly influence the clinical course, reducing the risk of sequelae and/or complications to the permanent teeth and providing a proper development of the dental arches [Caprioglio and Caprioglio, 2010].

The psychological approach towards the child and his/her parents is therefore of fundamental importance, as essential as the in-depth knowledge and the use of new technologies, that can simplify and/or improve both therapy and prognosis.

Since there is very little literature devoted to laser-assisted traumatology and there are no well-coded laser guidelines for these specific clinical events, it is the authors’ intention to propose, based on their own case studies and clinical research, the use of several laser wavelengths for multiple applications in dental traumatology.

Laser therapy may improve the psychological approach and the compliance of the patient, positively influencing both the objective and the subjective factors of pain, by raising the threshold of pain (inducing laser analgesia) and reducing discomfort [Genovese and Olivi, 2008].

For these reasons the use of laser in paediatric patients proved to be a valid method of intervention with a good level of patient acceptance during both hard and soft tissue therapy, as reported by several authors [Keller et al., 1998; Parkins, 2000; Takamori et al., 2003; Liu et al., 2006; Boj et al., 2005; Haytac and Ozcelik, 2006; Genovese and Olivi, 2008; Kara, 2008]. Even though this new technology is ideal for trauma-related problems, the existing dental trauma guidelines and protocols should nevertheless be widely consulted [Andreasen et al., 2007; Andreasen and Andreasen, 1990].

Laser-tissue interaction

Dental lasers, using different active mediums, emit light energy beams of different wavelengths: most of them belong to the invisible infrared range and some to the visible region of the electromagnetic spectrum (Fig. 1).

The different wavelengths interact differently on the target tissue, depending on optical affinity, coefficient of absorption, level of hydration and vascularisation of the different target tissues (gingiva, mucosa, pulp, enamel, dentin, curious tissue, bone).

Lasers with wavelengths in the visible zone and the first portion of the infrared electromagnetic spectrum (laser KTP, Diode, Nd:YAG e Nd:YAP), are well absorbed by the
pigment that are found in haemoglobin and melanin, and therefore are used mainly on soft tissues (incisions, vaporisation and coagulation), as well as for endodontic decontamination and tooth whitening.

Instead, lasers in the medium range of the infrared electromagnetic spectrum have a close affinity with water and hydroxyapatite: laser Er, Cr: YSGG and Er: YAG; for this reason they are used on hard tissues (conditioning and ablation) as well as on soft tissues (incision and vaporisation of the water content of the tissue), but with less haemostatic effect, due to the lack of affinity for haemoglobin [Coluzzi, 2004]. These lasers, which are definitely the most versatile, are also those most indicated in paediatric dentistry and traumatology.

Also the CO₂ (10600 nm) laser, in the far infrared spectrum, is selectively absorbed by water and is currently used only for incision and vaporization of soft tissues [Wilder-Smith P 1995]. Further reading of the literature is recommended to gain a deeper understanding of the modes of interaction of the different wavelengths on target tissue.

Laser in dental traumatology

Laser technology has many therapeutic indications in dental traumatology, both in emergency treatment and in everyday clinical practice, being considered an adjunct treatment as well as a viable alternative to traditional instruments in all phases following a dental trauma. Besides the therapeutic applications, laser technology represents an important diagnostic support: laser Doppler flowmetry is an experimental method that ascertains the status of pulp revascularisation, an important and controversial issue in dental trauma [Todea et al., 2008]. Laser technology is indicated in multiple clinical situations: from simple coronal fractures to fractures with pulp exposure, from different types of luxation to tooth reimplantation, from root fractures to the treatment of soft gingival reimplantation, from root fractures to the treatment of tooth discoloration, from the treatment of soft gingival tissue to the oral mucosa and perioral skin, often simplifying the procedures and reducing the intra- and post-operative sensitivity [Caprioglio et al., 2010].

Therefore all wavelengths used in dentistry can also be applied in traumatology; the lasers are classified as follows:

- Laser for soft tissues: KTP 532; diode 810, 940, 980; Nd:YAG 1064; Nd:YAP 1340; CO₂ 10600.
- Laser for soft and hard tissues: Er, Cr: YSGG 2780; Er: YAG 2940.
- Low level laser or laser for biostimulation: helium neon 635; diode 810 > 980.
- Laser for tooth whitening: KTP 532; diode 810 > 980.

According to the revised and published classification of dental injuries [IDC-DA, 3 ed. Geneva, WHO, 1995], that includes injuries to the teeth and supporting structures, to gingival and oral mucosa and based on anatomical, therapeutic and prognostic considerations, laser treatment can be useful in the following cases [Caprioglio et al., 2010]:

- Traumatic injuries to hard dental tissue and pulp.
- Traumatic injuries to the periodontal tissues.
- Injuries to gingiva or oral mucosa.

Laser advantages in dental trauma injuries

Several factors make laser therapy an elective procedure in dental traumatology, because besides completing or replacing normal dental procedures, above all it offers new treatment opportunities:

- It is minimally invasive and selective for different target tissues (dental tissue or soft tissue);
- It works without direct contact and vibration on the surface, reducing impact and stress on injured tooth;
- It works on injured tooth reducing the rise in temperature of pulp tissue, already stressed by the trauma (compared with the drill);
- It reduces dentinal sensitivity and permeability;
- It has high decontaminating action on both hard and soft tissues;
- It has high coagulating effect on both pulp and gingival tissues;
- It is safer than a rotating instrument or a blade when working in a small mouth that can move unpredictably;
- In many cases, the use of local anesthetics can be avoided;
- It may provide biostimulating and analgesic effect;
- It drastically reduces the need for post-operative medications compared with conventional procedures;
- It is well accepted by children and appreciated by the parents, who are enthusiastic about being able to offer their children the advantages of laser care.

Laser applications in dental traumatology

A professional and psychological approach to the patient includes an accurate diagnosis, a careful collection of dental history and clinical examination. The use of standardised charts is suggested, in order to save time and ensure that all aspects will be covered. Every phase of the clinical course, both pre- and post-treatment, must be fully documented to better monitor the patient, and also to draw a full medicolegal report should this be required.

Traumatic injuries to hard dental tissues and pulp

All treatments can be performed on both primary and permanent teeth, according to therapeutic guidelines.

Uncomplicated crown fracture

This type of fracture involves only the enamel, or both enamel and dentin, but not the pulp. It is the most common case in traumatology, often associated with trauma of the soft tissue; there is always the possibility of dislocation of a fragment in the soft tissue, making a dental radiograph essential, as in every clinical situations (Fig. 2). Er:YAG or Er,Cr: YSGG lasers are excellent devices for treating enamel and enamel-dentin crown fractures, thanks to the following advantages, in addition to those previously mentioned:

- Pulp temperature increases only minimally during laser treatment [Keller and Hibts, 1991; Hibst and Keller, 1996; Dostálová et al., 1997; Eversole et al., 1997; Ozturk et al., 2004];
- Laser irradiation provides high decontamination of the exposed site (bacterialidal effect) [Türkün et al., 2006; Moritz, 2006];
- Laser ablation removes smear layer and debris, leaving
allowing better composite adaptation.

Complicated crown fracture

Table 1 shows the parameters for vital pulp therapy and tooth preparation.

A complicated crown fracture involves enamel, dentin and exposes the pulp. Treatment will vary depending on the size of the exposure and the timeframe between trauma and treatment and includes:

- pulp capping,
- partial pulpotomy,
- pulpectomy and root canal therapy.

Dental trauma lesions paediatric dentistry are treated with the double aim of maintaining pulp vitality, ensuring the maturation of root and apex.

If the exposure is very small (<1mm²) and the treatment is provided within 24-48h, a pulp capping can be performed: Erbium and CO₂ laser are the first choice for the decontamination and coagulation of the exposed pulp, performed (without water) with very superficial thermal effect, which means a very small or no necrotic layer (Table 1); laser advantages in this procedure include also the limited rise in temperature in the pulp chamber during laser tooth preparation when the Erbium family lasers are used [Moritz, 1998; Olivi and Genovese, 2006; Olivi et al., 2007] (Fig. 3).

Pulpotomy is the treatment of choice for larger exposures (1>2mm²): by using diode, Nd:YAG, Erbium (with water) or CO₂ lasers, a pulpotomy can be carried out to provide a conservative treatment. Many studies confirmed the

![FIG. 3 - A 8.6-years-old male with complicated crown fracture of tooth 9. After Erbium laser coagulation of the pulp, the vital tissue was dressed with Ca (OH). Enamel and dentin were also treated with Erbium laser (courtesy of V. Lazzarini).](image)

<table>
<thead>
<tr>
<th>Power (W)</th>
<th>Energy (mJ)</th>
<th>Frequency (pps or Hz)</th>
<th>Spray</th>
<th>Operative Mode</th>
<th>Tip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tooth preparation</td>
<td>.8 - 1.8</td>
<td>60-80</td>
<td>10 &gt; 30Hz</td>
<td>yes</td>
<td>at focus</td>
</tr>
<tr>
<td>Margin Finishing</td>
<td>1.8-2.4</td>
<td>75-80</td>
<td>10 &gt; 30Hz</td>
<td>no</td>
<td>defocused</td>
</tr>
<tr>
<td>Root canal Decontamination Debriding</td>
<td>0.75-0.8</td>
<td>10Hz</td>
<td>yes</td>
<td>at focus</td>
<td>600-800 micron</td>
</tr>
<tr>
<td>Dentinal Sealing</td>
<td>0.25-0.3</td>
<td>25-30</td>
<td>10Hz</td>
<td>low</td>
<td>at focus per 5-10s</td>
</tr>
<tr>
<td>Pulpotomy</td>
<td>1.0-1.8</td>
<td>100-120</td>
<td>10 &gt; 15Hz</td>
<td>yes</td>
<td>at focus per 15-20s</td>
</tr>
<tr>
<td>Pulpectomy</td>
<td>0.20-0.5</td>
<td>20-30</td>
<td>2 &gt; 10Hz</td>
<td>no</td>
<td>defocused at 4-5mm</td>
</tr>
</tbody>
</table>

**TABLE 1 -** Indications for the later treatment of vital pulp and tooth preparation.
removal but provide better bactericidal effect of the root canal: the Nd:YAG penetrates for 1000 µ into the dentinal walls, and the 810 nm Diode laser decontaminate the dentin walls up to a depth of 750 microns [Schoop et al., 2004] (Fig. 4).

Uncomplicated and complicated crown-root fractures

These are fractures involving enamel, dentin, cementum and, when complicated, also the pulp. Laser-assisted therapy can be useful not only for coronal fragment restoration but also for supporting tissue surgery and endodontic therapy (gingivoplasty, gingivectomy, crown lengthening, etc.). In these clinical situations, visible, near and far infrared lasers (KTP, diode, Nd:YAG, CO₂ lasers) produce a better coagulation layer than medium-infrared lasers (Erbium lasers), which on the contrary are used for both bone and gingival surgery for root fragment exposure.

Traumatic injuries to the periodontal tissues

Concussion and subluxation

Traumatic injuries to the supporting structures of the mouth (alveolar bone, periodontum, gingiva, ligaments, fraenum and lips), defined as indirect traumas, can be effectively treated using lasers, especially the visible and near infrared lasers. They are used for their ability in decontaminating the periodontal defect following a dental luxation or sub-luxation, for decontamination of the alveolus following a traumatic avulsion, for the ability to perform microgingival surgery such as gingivectomy and gingivoplasty, and surgical incisions (e.g. to remove a tooth fragment) [Martens, 2003]. Also Erbium lasers equipped with special long tips are effective in treating periodontal defects as well as to remove granulation tissue, and to induce bleeding in post-extraction alveolar bone [Sasaki et al., 2002; Wang et al., 2005].

The bactericidal and detoxifying effects of the laser provide favourable conditions for restoring the injured
periodontal attachment (especially in permanent dentition). Reduction of inflammation and of postoperative pain, as well as activation of cell proliferation in the surrounding tissues, have also been reported [Kyzer et al., 1993; Simunovic et al., 2000; Kreisler et al., 2003].

When orthodontic splints are needed, Nd:YAG laser may have the advantage of non-traumatic debonding of the ceramic brackets.

If oral mucosa and gingival injuries are present, low level laser therapy (LLLT) can be used as well. This treatment helps the tissue repair process through cell proliferation activation and reduction of inflammation. LLLT can also reduce postoperative pain (analgiesic effect with transcutaneous irradiation) (Fig. 5).

Injuries to gingiva, oral mucosa or cutaneous tissue

Traditionally, these lesions are treated pharmacologically (with drugs or cicatrising products) or surgically (suturing). It is very useful to stop the bleeding with a KTP or CO2 laser before suturing. Furthermore LLLT helps faster healing and a prompt reduction of post-traumatic pain, reducing the need for medications (Fig. 6).

Non-vital dental bleaching

Dental traumas are at times associated with pulp necrosis and dark discoloration, due to the pulp oxidation process or to the endodontic cement pigmentation. Dental bleaching can be performed to improve aesthetics [Dostalova et al., 2003].

Photoassisted bleaching allows a light source to accelerate the action of a bleaching gel: KTP, Nd:YAG or diode laser can be used for this purpose [Zanin et al., 2003]. Infrared lasers activate the gel bleaching action through the increase in temperature (photothermal effect), while the KTP visible laser produces the chemical activation of the bleaching gel. The KTP laser for vital and non-vital bleaching can be used with high energy densities; the time needed for tooth bleaching is decreased, and therefore efficiency is improved [De Moor et al., 2009]. Laser-activated bleaching is an effective technique that is able to reduce the side effects of bleaching, and offers patients quick, comfortable and long-lasting results.

Conclusion

Laser technology, which we have used for ten years in our clinical settings, has been demonstrated to be effective in the treatment of dental trauma and, we believe, represents a gold standard in paediatric dentistry. In traumatology lasers offer an optimal treatment, minimally invasive on both hard and supporting tissue, reducing thermal shock to the pulp, producing a bactericidal effect on dental and periodontal tissue, providing an important analgesic effect and biostimulation for tissue healing, all of which increase patient compliance.

It is essential to be experienced, to follow the guidelines of dental traumatology to avoid imprecise or incautious movements. It is also crucial to know the different wavelengths and their interaction with biological tissues and to have undergone an adequate period of training and clinical practice to assure a safe and selective action to promote the optimal application of this technology.

References

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